Lecture 14
Relays

- Relays are electrically actuated switches
  - Mechanical relays
  - Reed relays
  - Solid-state relays

- A relay consists of an electromagnetic coil and one or more pairs of contacts
Mechanical Relays

- Designed for high currents
  - Typically from 2A to 15A
- Relatively slow switching
  - 10ms to 100ms

Contact switch
Common Symbols for Relays

- **SPST (normally open)**
- **SPST (normally closed)**
- **SPDT**
- **DPST (normally open)**
- **DPST (normally closed)**
- **DPDT**

Single Pole, Single Throw
Notes About Relays

• To make a relay change states, the voltage across of its magnetic coil should be at least within $\pm 25$ percent of the relay’s specified control voltage rating ($V_c \pm 0.25 \times V_c$)

• Sudden changes in current will create voltage spike, to avoid this is to use transient suppressors
Electromechanical Relay
Relays with BS2

Using an NPN transistor to drive a relay
Reed Relays

- Designed for moderate currents
  - Typically from 500mA to 1A
- Moderately fast switching
  - 0.2ms to 2ms
Solid State Relays

- Wide range of current ratings
  - from a few \( \mu \)A to 100A
- Extremely fast switching
  - 1 to 100 ns
Solid State Relay with AC

Extremely caution with 120V AC !!

Polytechnic

SMART Funded by The National Science Foundation
## Relay Experiments

<table>
<thead>
<tr>
<th>Experiments</th>
<th>Chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>What’s micro controller</td>
<td></td>
</tr>
<tr>
<td>Basic A and D</td>
<td></td>
</tr>
<tr>
<td>Earth measurements</td>
<td></td>
</tr>
<tr>
<td>Robotics</td>
<td></td>
</tr>
<tr>
<td>StampWorks</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>
Lecture 15
DC Motor

- DC motors are
  - Simple two-lead
  - Electrically controlled
- The voltage range of the DC motor is
  - 1.5V ~ 48V
DC Motor: How It Works

When electric current passes through a coil in a magnetic field, the magnetic force produces a torque which turns the DC motor.

Electric current supplied externally through a commutator

Magnetic force $F = LB$ acts perpendicular to both wire and magnetic field
Turning a DC Motor On/Off

![Diagram of a DC motor circuit with a transistor (BS2) controlling the current flow.](image)
DC Motor Speed Control 1

• When the voltage applied to a DC motor
  – Lower than nominal voltage → Motor runs slower
  – Higher than nominal voltage → Motor runs faster

• Linear control
  – Connect a potentiometer in series with motor
  – Use a transistor (BJT/FET) as a variable resistor
DC Motor Speed Control 2

Linear control using a potentiometer in series with motor
DC Motor Speed Control 3

Linear control using a bipolar transistor
Pulse Width Modulation 1

- An efficient method to deliver controlled amount of power to loads
- Use square voltage pulses to power a load
- The amount of power deliver to load depends on the duration of each pulse
Pulse Width Modulation 2

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>50k Potentiometer</td>
</tr>
<tr>
<td>M1</td>
<td>DC Motor</td>
</tr>
<tr>
<td>Q1</td>
<td>PNP Transistor</td>
</tr>
<tr>
<td>Q2</td>
<td>PNP Transistor</td>
</tr>
<tr>
<td>R1</td>
<td>1kΩ</td>
</tr>
<tr>
<td>R2</td>
<td>15kΩ</td>
</tr>
<tr>
<td>R3</td>
<td>12Ω</td>
</tr>
</tbody>
</table>
Pulse-Width-Modulation 3

Controlling on-time duration of a DC motor
Pulse-Width-Modulation 4

Full "on"

50% "on"

25% "on"

"Accelerating"

PWM